v. 5, n. 3, 2025

Journal of
Engineering
Research

Acceptance date: 24/02/2025

STUDY ON LOW VOLTAGE FUNDAMENTALS IN THE SUBJECT OF ELECTRICAL INSTALLATIONS. A CONTRIBUTION TO THE CAREER OF ELECTRICAL ENGINEERING TECNM, CAMPUS VERACRUZ

Alma Genoveva Castro Valdés
Master's Degree in Mechanical Engineering
Tecnológico Nacional de México (TECNM)
campus Veracruz, Veracruz, Mexico

Miguel Ángel Quiroz García
D. in Pedagogical Sciences - Tecnológico
Nacional de México (TECNM) - campus
Veracruz, Veracruz, Mexico

Angel Miranda Juarez
Master in Mechanical Engineering -
Tecnológico Nacional de México (TECNM)-
campus Veracruz, Veracruz, Mexico

Víctor Manuel de Jesús Leyva Negrete
Master of Science in Education - Universidad
CEULVER, Veracruz, Mexico

Violeta del Rocío Hernández Campos
Maste in Administrative Engineering -
Centro de Estudios Superiores de Veracruz
Veracruz, Mexico

Raymundo Escalante Wong
Degree in Electrical Engineering -
Tecnológico Nacional de México (TECNM)
- campus Veracruz, Veracruz, Mexico

All content in this magazine is licensed under a Creative Commons Attribution License. Attribution-Non-Commercial-Non-Derivatives 4.0 International (CC BY-NC-ND 4.0).

Abstract. - This study provides an overview of electrical systems, focusing on components, regulations and modern techniques applied to low voltage installations. Likewise, this study addresses various aspects of electrical installation, from basic theory to applied regulations. It also deals with the practical and theoretical techniques for designing and executing electrical installations in buildings, with emphasis on safety standards and low voltage components. This provides a complete guide to the design, regulation and maintenance of low voltage electrical installations, including diagrams, symbology and load calculations. NOM-001-SEDE-2012 is the Mexican standard that regulates low voltage electrical installations, addressing safety aspects, design and execution of these installations. This study is intended to serve as a support for the Electrical Installations subject covered in the first chapter. As a complement to the Teaching - Learning process, a questionnaire is attached that covers the fundamental aspects of low voltage electrical installations, and is designed to evaluate the understanding of the subject in the context of the academic study of TECNM, Campus Veracruz.
Keywords: Electrical installations, low voltage, electrical loads, electrical current, electrical elements.

INTRODUCTION

Low-voltage electrical installations are essential to ensure the power supply in residential, commercial and industrial buildings. These installations include all the systems that carry electricity from the distribution network to the electrical equipment inside buildings. This article covers the basic concepts of low voltage electrical installations, their classification and components, as well as their design and execution according to national safety standards.

DEVELOPMENT

This study covers the main points of the fundamentals of low voltage electrical installations, as shown in Figure 1.

LIGHTING, POWER AND GENERAL SERVICE ELECTRICAL LOADS IN BUILDINGS

Electrical loads in a low voltage installation refer to equipment and devices that consume electricity. These loads can be classified into different types:

Lamps and luminaires: These are essential components of lighting in buildings. The selection of lamps and luminaires depends on factors such as energy efficiency, brightness and light distribution

Tipo de ocupación	Carga unitaria (VA/m^2)
Cuarteles y auditorios	10
Bancos	38 **
Barberías y salones de belleza	32
Iglesias	10
Clubes	22
Juzgados	22
Unidades de vivienda *	32
Garajes públicos (propiamente dichos)	5
Hospitales	22
Hoteles y moteles, incluidos bloques de apartamentos sin cocina *	22
Edificios industriales y comerciales	22
Casas de huéspedes	16
Edificios de oficinas	38 **
Restaurantes	22
Colegios	32
Tiendas	32
Depósitos	2.5
En cualquiera de los lugares anteriores excepto en viviendas unifamiliares y unidades individuales de vivienda bifamiliares y multifamiliares:	
Lugares de reunión y auditorios	10
Recibidores, pasillos, armarios, escaleras	5
Lugares de almacenaje	2.5

electricaplicada.com

Table1 Lighting loads in general by type of occupancy
https://electricaplicada.com/diseno-electrico-para-una-vivienda-casa/

Fractional and low-power motors for cooling, ventilation and water pump equipment: Low-power motors are responsible for the operation of equipment such as fans, cooling systems and water pumps, which are essential for comfort in buildings.

Building elevators: Power supply is crucial for the operation of elevators in buildings, which require a robust and safe electrical installation.

5.- OBJETIVO GENERAL DEL CURSO

Elaborar proyectos de instalaciones eléctricas de baja tensión de usos generales de aplicación residencial, comercial y de servicios públicos, de acuerdo con la normatividad vigente y empleando paquetes de cómputo adecuados.

7.- TEMARIO

Unidad	Temas	Subtemas
1	**Fundamentos de las Instalaciones Eléctricas de Baja Tensión**	1.1 Cargas eléctricas de iluminación, motrices y de servicios generales en edificios. Clasificación general: • Lámparas y luminarias • Motores fraccionarios y de baja potencia para equipos de refrigeración, ventilación y bombas de agua • Elevadores de edificios • Resistencias para calefacción • Equipo eléctrico/electrónico sensible 1.2 Componentes y elementos eléctricos de baja tensión: • Acometidas, medidores, interruptores, cables, canalizaciones y registros 1.3 Tableros de distribución, ductos, electro-ductos, contactos y conexiones a equipos 1.4 Simbología, diagramas unifilares y reglamentación NOM 1.5 Censos y estimaciones de carga de iluminación, refrigeración y servicios generales • Energía específica de bienes y servicios en kWh/unidad • Carga/m² de iluminación • Carga/m³ de calefacción y refrigeración 1.6 Demandas y factores de demanda 1.7 Tarifas de servicio para uso general. Aspectos generales: • Aplicaciones, capacidades y disponibilidad de suministro • Tensiones eléctricas normalizadas • Facturación 1.8 Acometidas de Servicio • Monofásicos 2 y 3 hilos • Trifásicos 4 hilos

Figure 1 Official syllabus of chapter 1 of the subject Electrical Installations

Heating resistors: In electric heating systems, resistors convert electrical energy into heat, which is necessary to maintain a suitable temperature inside the building.

Sensitive electrical/electronic equipment: Equipment such as computers, servers and other electronic devices require a stable and protected power supply to avoid damage from fluctuations or overloads.

LOW VOLTAGE ELECTRICAL COMPONENTS AND ELEMENTS

Low voltage electrical components and elements (see table 2 and 3) are the devices that allow the distribution, protection and control of electrical energy within a building. Some of these elements are:

- Connections: These are the connections between the public power grid and the building's internal installation. They are responsible for providing power from the grid to the internal systems.
- Meters: Instruments used to measure the electricity consumption in a building, which are generally installed in the connection of the installation.
- Switches: Safety devices that allow opening or closing the electrical circuit, protecting the installation from overloads or short circuits.
- Cables and conduits: Cables enable the transmission of electricity from the distribution panel to the equipment, and conduits protect these cables from mechanical or environmental damage.

• Registers: Spaces or boxes where cables and connections are grouped, facilitating maintenance and protection of electrical installations.

DISTRIBUTION PANELS, DUCTS , ELECTRODUCTS, CONTACTS AND EQUIPMENT CONNECTIONS

Distribution boards are essential in the management of electricity within a building. These devices group switches and protection devices to distribute electrical power to different circuits. In addition, other components such as ducts and conduits are used to protect and organize the cables. Contacts and equipment connections, as shown in Figure 2, allow electrical devices to be safely connected to the installation.

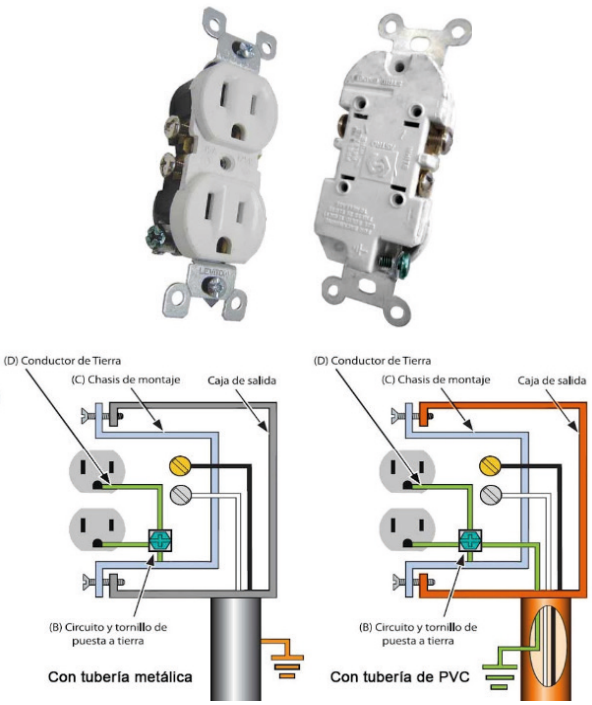

Figure 2.- Ducts, Contacts and Equipment Connections

https://instalacioneselctricasresidenciales.blogspot.com/2010/03/contactos-con-tierra-aislada-para.html

SYMBOLOGY, UNIFILAR DIAGRAMS AND NOM REGULATIONS

It is essential that low voltage electrical installations follow strict regulations Symbology: There are standardized symbols to represent the different electrical components in the drawings, which facilitates the interpretation and execution of projects.

Single-wire diagrams: These are simplified diagrams showing the distribution of electrical power in a single wire. These diagrams allow (see examples in figure 3) a clear visualization of the power flow and protection devices.

NOM regulations: In Mexico, the Norma Oficial Mexicana (NOM) establishes the technical guidelines for the installation of electrical systems, ensuring that safety and efficiency standards are met.

LIGHTING, REFRIGERATION AND GENERAL SERVICES LOAD CENSUS AND ESTIMATES

Census and load estimates allow determining the amount of electrical energy needed to operate a building efficiently. Below, Lighting Load estimates are shown in Table 4; some key aspects include:

Table 5 shows the main rejection factors for open compressors.

Specific energy of goods and services in kWh/unit: The electricity consumption per unit of each device or service, such as lamps or refrigeration equipment, is calculated.

Lighting load/m^2: This is the amount of energy required to illuminate a given area of the building, and is calculated to ensure an adequate level of brightness.

Heating and cooling load/m^3: In buildings with heating or air conditioning systems, the electrical load required to maintain a comfortable temperature is calculated.

Cargas	Focos 100 W	Contactos 180 VA	Bomba de agua	Lavadora	Horno de microondas	Totales
Cantidad	20	24	1	1	1	
Potencia	2000 W	4320 VA	1460.5 VA	1460.5 VA	1524 W	10765 VA
Corriente	16.7 A	36 A	12.2 A	12.2 A	12.7 A	89.8 A

Carga total 10,765 VA		
Primeros 3000 VA	100%	3000 VA
Restantes 7765 VA	35%	2,717.75 VA
Demanda máxima		5,717.75 VA

Tables 2 and 3.- Low-voltage electrical components and components
https://instalacioneselctricasresidenciales.blogspot.com/2013/05/5-pasos-para-calcular-la-preparacion.html

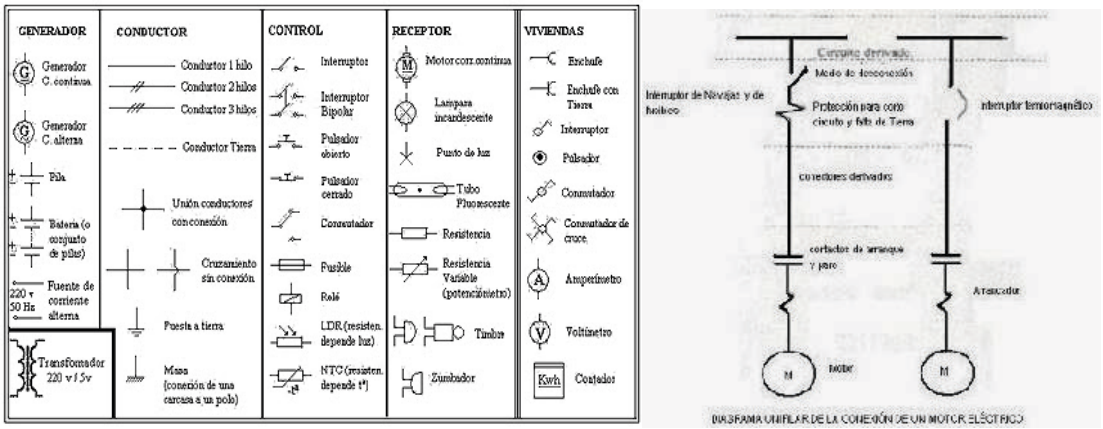

Figure 3.- Unifilar Diagrams and Symbology
https://electroitch.blogspot.com/2013/11/diagrama-unifilar-y-simbologia.html

Potencia eléctrica en circuitos de 120 voltios - note excepciones

Aparato	Amperios	Watts	Aparato	Amperios	Watts
Aire acondicionado (central)	13 a 36 (240-v)	3,120 a 8,640	Trituradora de basura	3.5 a 7.5	420 a 900
Aire acondicionado (ventana)	6 a 13	720 a 1,560	Secador de cabello	5 a 10	600 a 1,200
Licuadora	2 a 4	240 a 480	Calentador (portátil)	7 a 12	840 a 1,440
Asador	12.5	1,500	Horno microondas	4 a 10	480 a 1,200
Abridor de latas	1.2	144	Estufa (horno/estufa)	5.5 a 10.8 (240-v)	1,320 a 2,600
Sierra circular	10 a 12	1,200 a 1,440	Refrigerador	2 to 4	240 to 600
Cafetera	4 a 8	480 a 960	Rutiladora	8	960
Secadora de ropa	16.5 a 34 (240-v)	3,960 a 8,160	Lijadora (portátil)	2 a 5	240 a 600
Plancha de ropa	9	1,080	Sierra (de mesa)	7 a 10	840 a 1,200
Computador	4 a 7	480 a 840	Máquina tejedora	1	120
Lavaplatos	8.5 a 12.5	1,020 a 1,500	Estéreo	2.5 a 4	300 a 480
Taladro (portátil)	2 a 4	240 a 480	Televisión	2.5	300
DVD	2.5 a 4	300 a 480	Tostadora	9	1,080
Ventilador (de techo)	3.5	420	Compactador de basura	4 a 8	480 a 960
Ventilador (portátil)	2	240	Aspiradora	6 a 11	720 a 1,320
Congelador	2 a 4	240 a 600	Wafflera	7.5	900
Sartén	9	1,080	Lavadora de ropa	12.5	1,500
Aire acondicionado (de gas)	6.5 a 13	780 a 1,560	Calentador de agua eléctrico	15.8 a 21 (240-v)	3,800 a 5,040

Table 4.- Lighting Load Estimates
https://giasenergi.blogspot.com/2021/12/cuadro-de-cargas-electricas.html

CUADRO 1. FACTORES DE RECHAZO DE CALOR PARA COMPRESORES ABIERTOS.

TEMPERATURA EVAPORADOR EN °F	TEMPERATURA DEL CONDENSANTE EN °F					
	90	100	110	120	130	140
-30	1.37	1.42	1.47			
-20	1.33	1.37	1.42	1.47		
-10	1.28	1.32	1.37	1.42	1.47	
0	1.24	1.28	1.32	1.37	1.41	1.47
10	1.21	1.24	1.28	1.32	1.36	1.42
20	1.17	1.20	1.24	1.28	1.32	1.37
30	1.14	1.17	1.20	1.24	1.27	1.32
40	1.12	1.15	1.17	1.20	1.23	1.28
50	1.09	1.12	1.14	1.17	1.20	1.24

Table 5.- Refrigeration and General Services; rejection factors for open compressors
https://losmejorestecnicosjunior.blogspot.com/2015/10/seleccion-de-componentes-en.html

TABLA RESUMEN DE DEMANDAS ENERGÉTICAS MENSUALES DEL EDIFICIO								
Mes	Demanda Ref. (kWh)	Demanda Cal. (kWh)	Consumo E. final Ref. (kWh)	Consumo E. final Cal. (kWh)	Consumo E. primaria Ref. (kWh)	Consumo E. primaria Cal. (kWh)	Emisiones CO2 Ref. (kg)	Emisiones CO2 Cal. (kg)
Enero	0,0	4.128,6	0,0	4.503,2 / 175,3	0,0	5.324,2	0,00	1.406,17
Febrero	0,0	2.535,6	0,0	2.774,4 / 104,6	0,0	3.271,4	0,00	864,14
Marzo	0,0	1.440,2	0,0 / 0,7	1.580,7 / 56,2	1,8	1.855,1	0,44	490,16
Abril	201,6	652,5	77,7 / 7,0	718,4 / 22,4	220,4	834,9	54,95	220,73
Mayo	1.266,1	109,1	457,2 / 31,4	120,4 / 3,0	1.271,8	137,9	317,10	36,48
Junio	3.636,6	0,0	1.266,4 / 73,0	0,0	3.486,6	0,0	869,30	0,00
Julio	10.296,6	0,0	3.124,6 / 113,3	0,0	8.428,4	0,0	2.101,44	0,00
Agosto	11.037,7	0,0	3.211,7 / 115,2	0,0	8.659,9	0,0	2.159,14	0,00
Septiembre	4.976,9	0,0	1.570,7 / 74,7	0,0	4.282,8	0,0	1.067,82	0,00
Octubre	574,6	54,7	212,8 / 21,5	60,4 / 2,5	609,7	71,7	152,02	18,94
Noviembre	5,3	1.491,6	2,8 / 0,9	1.637,8 / 60,9	9,6	1.929,0	2,39	509,58
Diciembre	0,0	3.543,7	0,0 / 0,0	3.869,9 / 149,0	0,1	4.571,2	0,02	1.207,36
Total anual	31.995,4	13.956,0	9.923,8 / 437,7	15.265,2 / 573,9	26.971,0	17.995,4	6.724,62	4.753,55

Table 6. Summary of monthly energy demands of a building
https://www.imventa.com/Ayuda/TeKton3D/Modulos/Capitulos/CDT/ResultadosCrearListadoDemandasEnergeticasMensuales.htm

ELECTRIC POWER DEMAND AND DEMAND FACTORS

Demands refer to the maximum amount of energy that can be required at a given time by the facility. Demand factors are used to estimate electricity consumption as a function of the type of building and its use (Figure 6). This allows for proper sizing of the electrical installation components.

Figure 4 Service Rates for General Use. General Aspects
https://www.youtube.com/watch?v=ag-G--JlUS2k&ab_channel=PeriodicoHechosColima

RATES FOR THE SERVICE

Electricity service rates vary according to the type of user and energy consumption. General aspects include:

Applications, capacities and supply availability: Depending on the energy demand, tariffs may vary, and the different types of contracts with the supplying company must be considered.

Standardized electrical voltages: In low voltage installations, there are standard voltages to ensure safety and compatibility with electrical devices.

Billing: Electricity billing is based on metered consumption, applying specific rates according to type of use.

ELECTRICAL SERVICE CONNECTIONS

There are different types of service connections to bring electricity from the public grid to the internal installation of buildings:

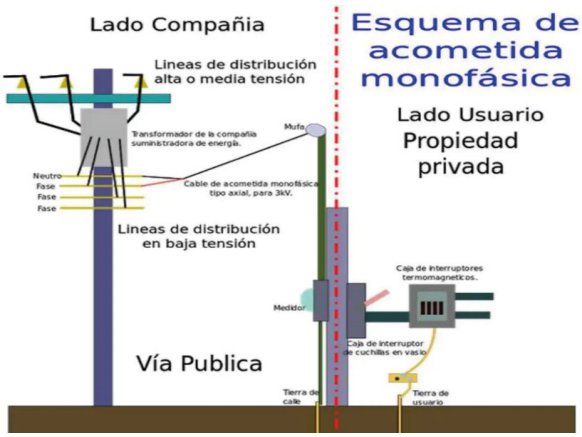

Figure .5 Diagram of Single Phase Electrical Service Connections

https://500x20.prouespeculacio.org/acometida-electrica-vivienda-destacada2/

Single-phase 2 and 3-wire: In small or residential buildings, single-phase connections are used, which distribute electrical energy by means of two or three wires.

Three-phase 4-wire: In commercial or industrial buildings, where a higher power capacity is required, three-phase 4-wire connections are used, allowing a more efficient and balanced load distribution.

PREDICTIVE MAINTENANCE

Predictive maintenance focuses on predicting when equipment or assets are likely to fail, using techniques such as vibration analysis, thermography and oil analysis. This allows maintenance to be performed before a failure occurs, reducing downtime and repair costs.

> - "Predictive maintenance is a powerful tool for reducing downtime and improving equipment efficiency" (Mobley, 2002).

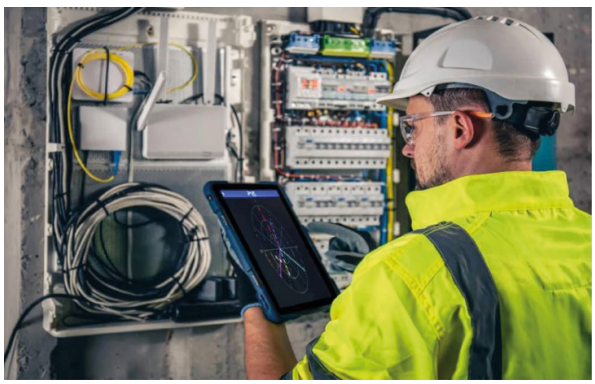

Figure 6.- Predictive Maintenance of Electrical Installations

https://ocimaq.mx/mantenimiento-electrico-industrial-ec0215/

PREVENTIVE MAINTENANCE

Preventive maintenance focuses on performing regular maintenance tasks to prevent failures and prolong equipment life. This may include tasks such as lubrication, cleaning and inspection of equipment.

> - "Preventive maintenance is an effective way to reduce maintenance costs and improve equipment availability" (Nakajima, 1998).

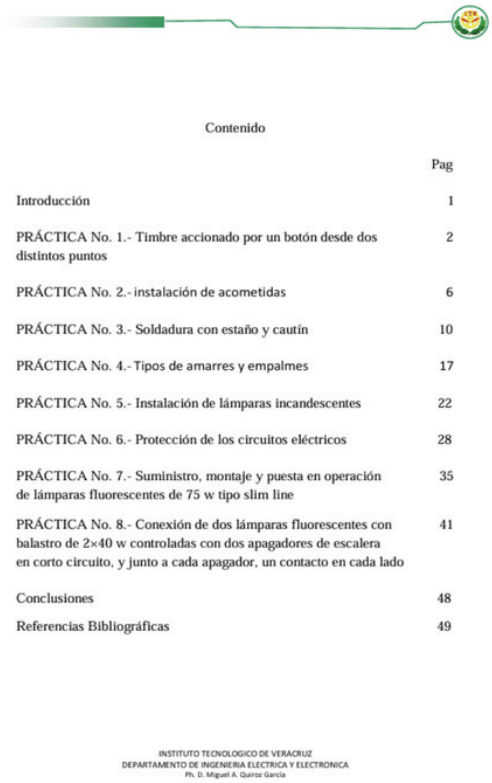

Figure 9.- Internship Manual and List of Internships

Prepared by the author of the research

Figure 7.- Preventive maintenance of electrical installations https://www.jovalindustrial.com/blog/important-generator-maintenance-tips/

CORRECTIVE MAINTENANCE

Corrective maintenance focuses on repairing or replacing equipment or components that have failed. This can be costly and may require time to perform the repair.

- "Corrective maintenance is a reactive form of maintenance that can be costly and may require time to perform the repair" (Welte, 1997).

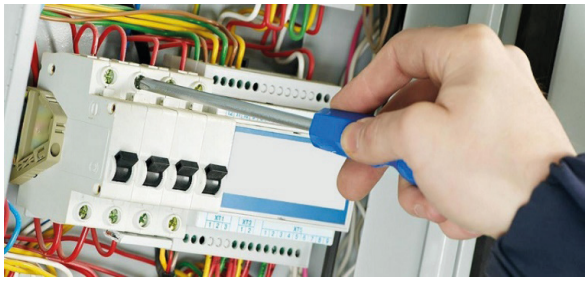

Figure 8.- Corrective Maintenance of electrical installations https://solucioneselectricas.azurewebsites.net/mancrr.html

PRACTICE MANUAL

As part of the subject of electrical installations, a practice manual has been prepared containing the following 8 practices, their conclusion and bibliographical references.

The practice manual lists the following items:

ELECTRICAL INSTALLATIONS

PRACTICE No. 1.- Bell operated by a button from two different points.

PRACTICE No. 2.- Installation of connections.

PRACTICES No.3.- Soldering with tin and soldering iron.

PRACTICE No.4.- Types of ties and splices.

PRACTICE No. 5 - Installation of incandescent lamps.

PRACTICE No. 6.- Protection of electrical circuits.

PRACTICE No.7.- Supply, installation and commissioning of 75 w Slim line fluorescent lamps.

PRACTICE No.8.- Connection of two 2x40 w fluorescent lamps with ballast controlled with two short-circuit ladder dampers, and next to each damper, one contact on each side.

CONCLUSIONS

Low voltage electrical installations are essential for the safe and efficient operation of electrical systems inside buildings. It is crucial to know both the components of the installation and the current regulations, as well as to make a correct estimation of the electrical loads and demand in order to properly size the systems. The correct application of these principles ensures a reliable and safe electrical supply for all users.

REFERENCES

1.- Álvarez, F., & García, J. (2017). Tecnología de las instalaciones eléctricas. Editorial McGraw-Hill.

2.- Crespo, M. (2018). Diseño y cálculo de instalaciones eléctricas de baja tensión. Editorial Paraninfo.

3.- Gómez, R., & Martínez, A. (2020). Instalaciones eléctricas en edificios: Teoría y práctica. Editorial Alfaomega.

4.- Instituto Nacional de Normalización (2021). Norma Oficial Mexicana NOM-001-SEDE-2012: 5.- Instalaciones Eléctricas (utilización). Secretaría de Economía.

6.- Kumar, S. (2013). Maintenance Management. CRC Press.

7.- López, M. (2019). Instalaciones eléctricas de baja tensión: Fundamentos y aplicaciones. Editorial Reverte.

8.- Mobley, R. K. (2002). Maintenance Fundamentals. Butterworth-Heinemann.

9.- Nakajima, S. (1998). Total Productive Maintenance. Productivity Press.

10.- Serrano, J., & Fernández, C. (2016). Manual de instalaciones eléctricas de baja tensión: Normativa, diseño y mantenimiento. Editorial Paraninfo.

11.- Welte, T. (1997). Maintenance Planning and Scheduling. Industrial Press.

ANEXO A- CUESTIONARIO

1.- ¿Qué se entiende por instalaciones eléctricas de baja tensión?

Respuesta: Las instalaciones eléctricas de baja tensión son aquellas que operan a un voltaje inferior a 1,000 V en corriente alterna (CA) o 1,500 V en corriente continua (CC), y se utilizan para suministrar energía eléctrica a viviendas, oficinas, comercios e industrias.

2.- ¿Cuáles son los componentes principales de una instalación eléctrica de baja tensión?

Respuesta: Los principales componentes son: el sistema de distribución, cables o conductores, interruptores automáticos, enchufes, interruptores, cajas de conexión, cuadros de distribución y dispositivos de protección.

3.- ¿Cuál es la función de los interruptores automáticos en las instalaciones eléctricas?

Respuesta: Los interruptores automáticos protegen las instalaciones eléctricas contra sobrecargas y cortocircuitos, desconectando el circuito en caso de un fallo, evitando daños mayores o incendios.

4.- ¿Qué normas rigen las instalaciones eléctricas de baja tensión en México?

Respuesta: Las instalaciones eléctricas de baja tensión en México deben cumplir con la NOM--001-SEDE, que establece los requisitos para la seguridad de las instalaciones eléctricas y la Norma Oficial Mexicana 002, que regula las características técnicas de los cables.

5.- ¿Qué importancia tiene el cálculo de la corriente en el diseño de una instalación eléctrica de baja tensión?

Respuesta: El cálculo adecuado de la corriente es crucial para seleccionar los cables y dispositivos adecuados para garantizar que la instalación pueda manejar la carga sin sobrecalentamientos o riesgos de fallos, asegurando la seguridad y eficiencia del sistema.

6.- ¿Qué es el aterrizaje de una instalación eléctrica y por qué es importante?

Respuesta: El aterrizaje es la conexión de una parte del sistema eléctrico a tierra, proporcionando una vía segura para la corriente en caso de fallos. Esto previene accidentes eléctricos y protege a las personas de descargas eléctricas peligrosas.

7.- ¿Cuáles son los peligros más comunes asociados con una instalación eléctrica de baja tensión mal realizada?

Respuesta: Los peligros incluyen incendios debido a sobrecalentamientos, electrocución por contacto con cables defectuosos o mal aislados, y fallos en equipos por sobrecargas o cortocircuitos.

8.- ¿Qué requisitos deben cumplir los cables en una instalación eléctrica de baja tensión?

Respuesta: Los cables deben ser adecuados para el tipo de corriente, tener una capacidad de conducción que no genere calentamiento excesivo, estar aislados correctamente para evitar cortocircuitos y ser resistentes a factores como la humedad, la temperatura y la abrasión.